Space Weather Technical Forecast

Issued on Monday, 03 October 2022 at 13:18 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: G1/G2 Minor-Moderate storms likely on Day 1 and Day 2. Ongoing likelihood of M-class flares with chance of X-class flares due to AR3110 and AR3112.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Strong over the last 24 hours, with an X1.0 at 02/2015 UTC from AR3110 Dac/Beta in the northwest. This is a relatively small region which has simplified a little since this flare. Low M-flares were also observed from AR3112 Fkc/Beta-gamma-delta, a longitudinally wide spot in the northeast disc. This appears comprised of a string of umbral and penumbral regions, with a larger more compact intermediate region with ongoing development. There are nine sunspot regions on the disc, with eight numbered, including AR3112 and AR3110, and one newly developing region. There are several large filaments on the disk, especially in the south which will require monitoring for any potential lift.
In the last 24 hours, two potentially Earth-directed CMEs have been observed leaving the Sun, due to the M8.3 and X1.0 flares. The latter has yet to be analysed, with the former likely missing but with a chance of a glancing arrival early on the 4th. These CMEs may combine with those already en-route that were observed leaving the Sun on the 1st.

Solar Wind / Geomagnetic Activity: Solar wind parameters at L1, as measured by DSCOVR/ACE, have remained at slightly-elevated to elevated levels, between 450 km/s and 600 km/s. This may be due to impacts of CH28/+. Density has been average or below average. The total IMF, Bt, was mostly weak at 5-8nT, but climbed to moderate levels of 12nT at 03/1000 UTC. The north-south component, Bz, varied between -8 to +6nT. The phi angle was positive (away from the Sun). The resultant geomagnetic activity was mainly Quiet to Unsettled (Kp 0-3), but rose to G1/Minor Storm (Kp5) at 03/2100-2359 UTC.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) as measured at GOES16, is currently just above normal background levels, but well below the S1/Minor Storm threshold having slightly increased in response to the X1.0 flare of AR3110. High energy electron flux (greater than 2 MeV) was at background levels. The associated 24-hour fluence remained well below the Active (1e8 integrated pfu) threshold. Observed fluence at 03/0001 UTC was 1.28e6 integrated pfu.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.

Met Office Space Weather Technical Forecast

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is forecast to be Moderate to High, with further M-flares or perhaps X-flares possible from AR3110 and AR3112.

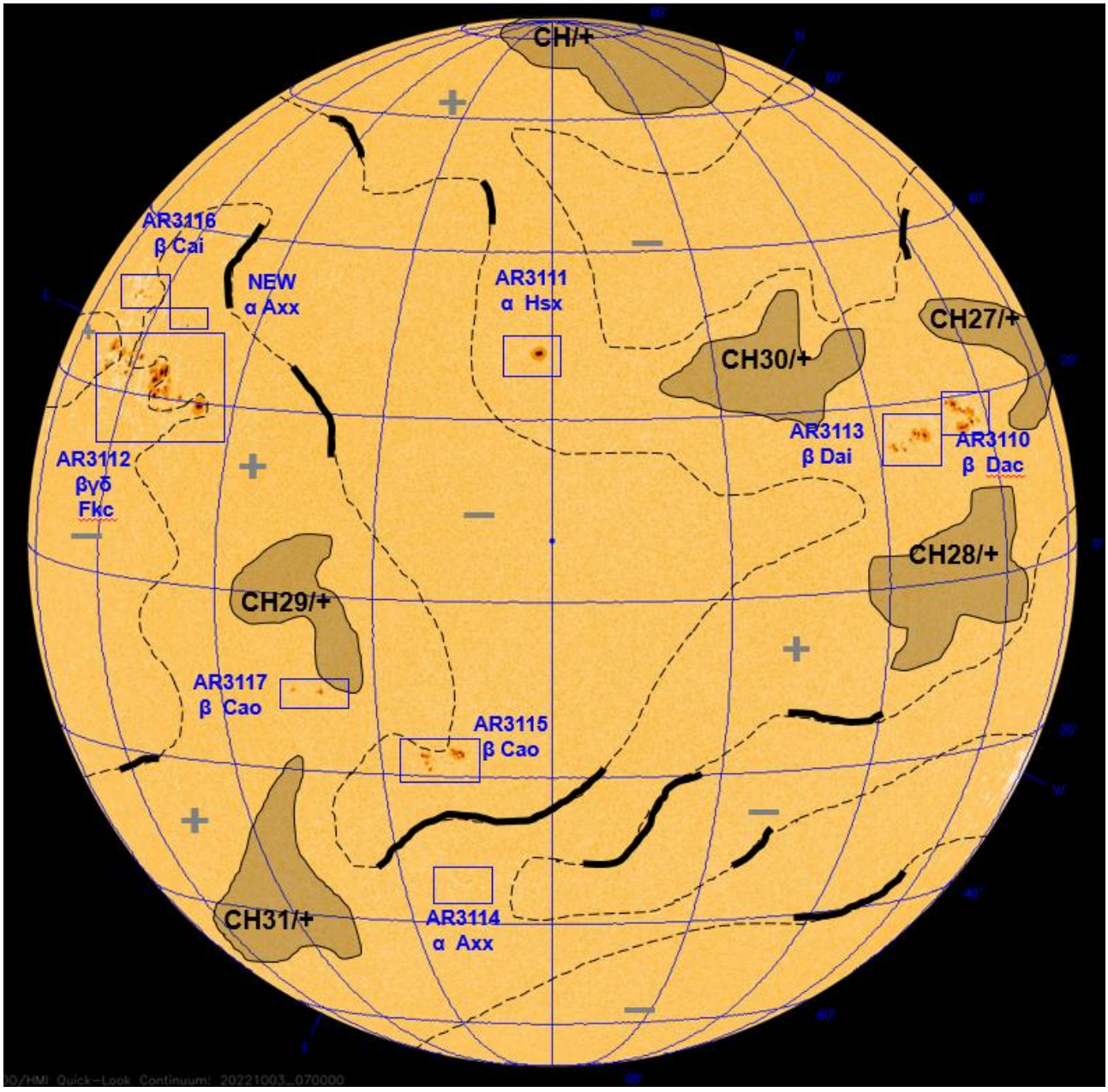
Solar Wind / Geomagnetic Activity: There are potentially four CMEs in which could influence Earth. The most notable was from a filament eruption to the east of AR3113 around 01/1200 UTC, and will potentially arrive late on day 1 (3rd) or early day 2 (4th), although this is low confidence with glancing impacts possible. Further CMEs from the M and X-flaring of AR3110 on the 1st and 2nd follow, however these are lower confidence for arrival, but may combine with the first arrival to give further enhancement through day 2 (4th). The uncertainty around these CMEs gives very low confidence in the forecast. Otherwise current fast winds are expected to only gradually ease during day 3 and day 4 (5th and 6th), though probably remaining slightly elevated until the end of the period. Geomagnetic activity is forecast to be mainly Unsettled to Active with G1-G2 Minor to Moderate Storms possible through to day 2 (3rd-4th) associated with any CME arrival, perhaps ongoing into day 3 (5th). Otherwise, a general trend back towards Quiet, with isolated Unsettled intervals is expected later day 3 and day 4 (5th-6th).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10MeV) is expected to be near background for much of the period, but with further small enhancements likely, and slight chance of rising above the S1 level through the period due to any further M or X-flares that occur, mainly from AR3110 or AR3112. The high energy (greater than 2MeV) electron flux has been at background levels, and is likely to rise due to the recent fast wind arrival. In the absence of any CMEs, this would occur later day 1 and through the rest of the period, with an increasing chance of flux becoming persistently High. However, this is uncertain due to the potential CME impacts, with any rise likely occurring once their influence subsides. The associated 24 hour fluence will likely stay below the Active threshold until at least day 3 or day 4 (5th or 6th), but with an increasing chance of rising above.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.

Figure 1. Solar Analysis Valid 03/0700 UTC.



.

Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.

Geomagnetic Storms:

Four CMEs have erupted from the northwest quadrant in the past 24 hours, with the potential for Earth-directed ejecta, although uncertainty remains high. The most likely to impact originated from a filament eruption to the east of AR3113 at 01/1200 UTC. Two further CMEs from AR3110 associated the M5.8 and M8.3 flares at 01/2010 and 02/0220 UTC are mainly directed away from Earth, however these have a chance to give glancing impacts. A further CME from the X1.0 of AR3110 at 02/2025 UTC has been analysed missing Earth. A CME from a filament eruption later on the 2nd has not been analysed yet but is likely to miss.

The first CME is the most likely to provide impacts at Earth, arriving either late on day 1 (3rd) or early day 2 (4th). This is slightly earlier than previous forecast due to a slight adjustment to the previous analysis, and also the earlier arrival of the fast wind of CH28, suggesting faster background winds. Confidence remains low on the strength of any impact. The following CMEs are likely to only give glancing impacts at most, although perhaps re-enhancing conditions through day 2 and into day 3 (4th to 5th) after the initial arrival, although this is also very low confidence.

Earth has been in the fast wind of CH28, with slightly elevated or elevated solar winds expected to persist into day 4 (6th). There remains a great deal of uncertainty due to the low confidence surrounding CME arrival times and impacts.

Geomagnetic activity is forecast to be mainly Unsettled to Active day 1 and 2 (3rd-4th) with G1-G2 Minor to Moderate Storms likely with any CME arrival. Ongoing CME effects would then follow into day 3 (5th) if this arrival occurs, although there is significant uncertainty. Otherwise, a general trend back towards Quiet, with isolated Unsettled intervals is expected later day 3 and day 4 (5th-6th).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	60	60	20	5
Strong	G3	No	15	15	1	1
Severe	G4	No	2	2	1	1
Extreme	G5	No	1	1	1	1

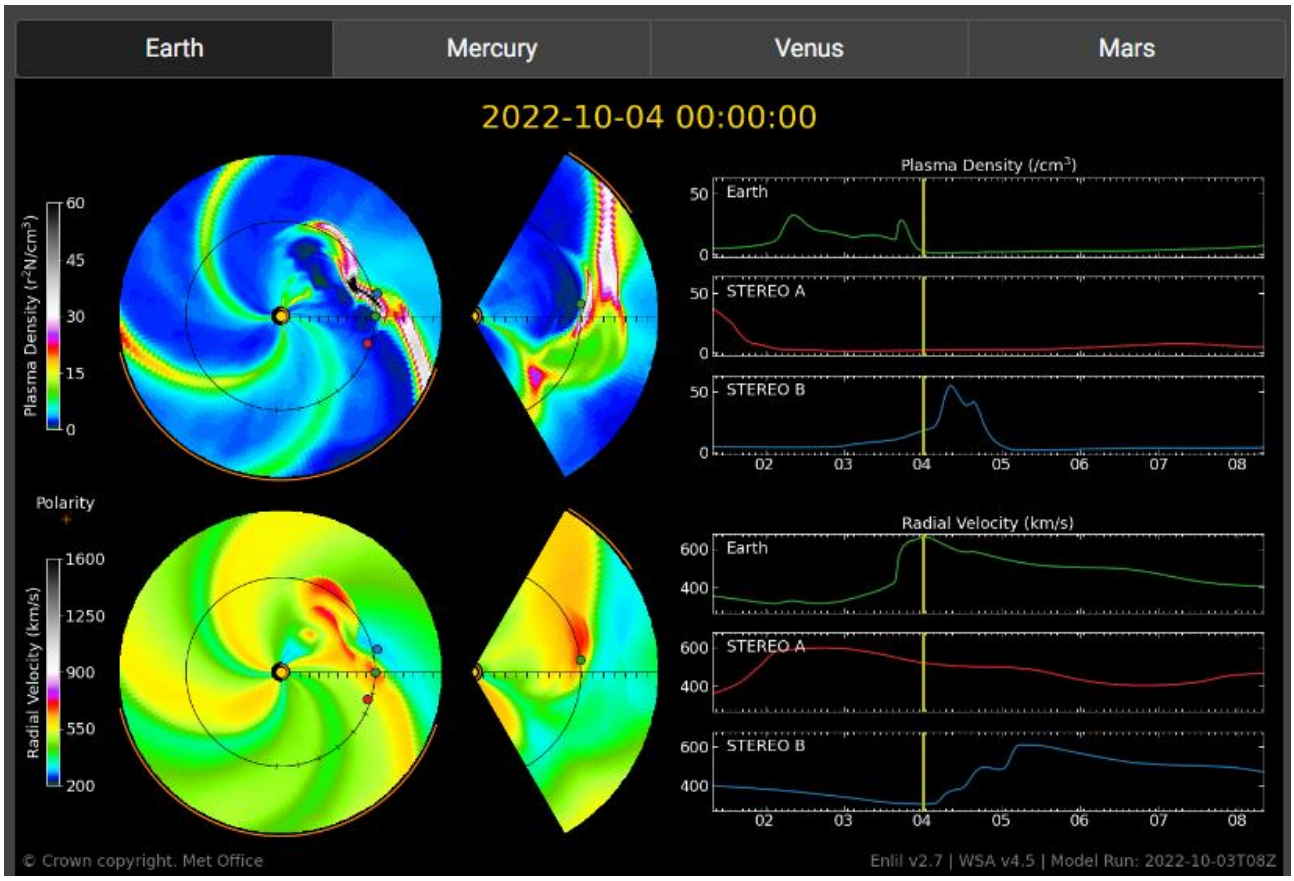
Geomagnetic Activity - Earthbound Coronal Mass Ejections- Note other CMEs may combine to enhance impact.

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
01/1625UTC	Partial Halo	AR3113	MW	1000km/s	03/2359UTC +/- 12 hours	Low confidence glancing blow.

Figure 2: MOSWOC Enlil: There remains a good deal of uncertainty regarding CME arrival time.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

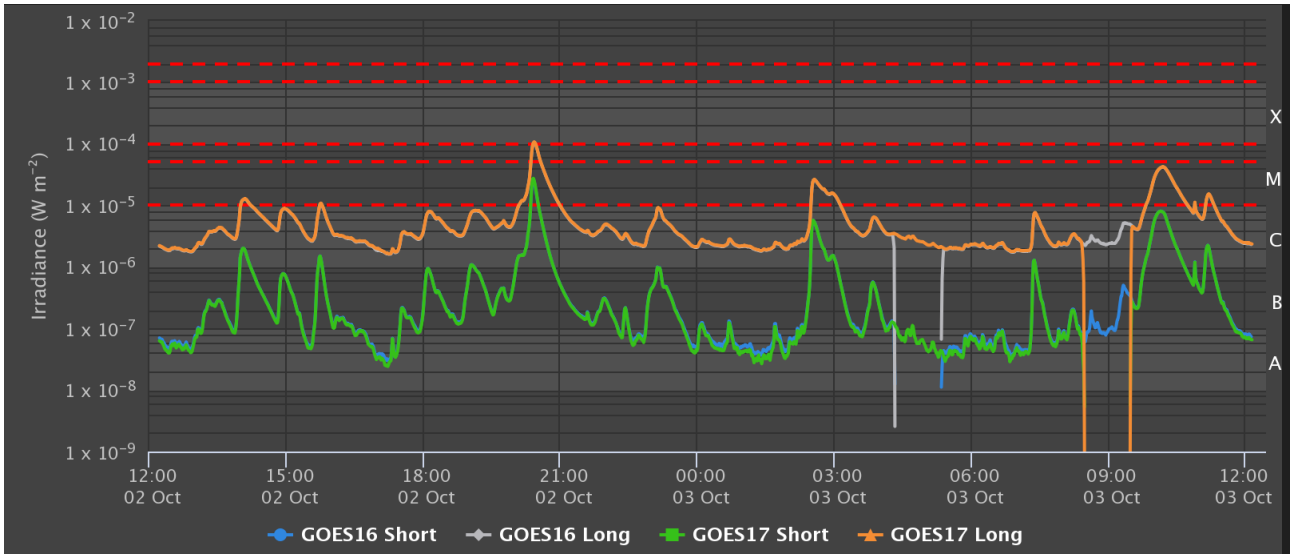
© Crown Copyright 2022. All Rights Reserved.

Radio Blackouts - X-Ray Flares:
There are eight numbered region on the Earth-facing disc. Activity has been Strong with AR3110 Dac/Beta the source of an X1.0 at 02/2025 UTC and a number of M-flares. This region has simplified a little since the flare, though the flare risk remains, especially due to its close proximity to nearby AR3113 Dai/Beta to the east, with a magnetic connection likely between the two regions.
AR3112 Fkc/Beta-gamma-delta in the northeast is also of notable interest, due to its large longitudinal length and recent low level M-flaring. This region consists of a long string of spots, with development still ongoing, particularly around a larger, more compact intermediate region. While not as compact or complex as the top-level Fkc region, this still has the potential for M, and perhaps X-flares.

Along with the other, less notable regions, these give a chance of further X-flares through the period, with M-flares also likely each day and activity is expected to remain Moderate to Strong.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	80	80	70	70
Very Active	R3 to R5 X Class	Yes	30	30	25	25

Figure 3: GOES16 X-Ray flares



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.

Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10MeV) as observed by GOES16 rose slightly above background due to the X-flare of AR3110 on the 2nd, but well below the S1-level. Further such rises are expected with a slight chance of exceeding this threshold, primarily from any further M or X-flares from AR3110, but potentially also from AR3112 in the northeast given a sufficiently strong flare event.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	20	20	15	15
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

The high energy (greater than 2MeV) electron flux has been at background levels. Any rise in electron flux due to the slightly elevated wind speeds will be complicated by the potential CME arrivals later day 1 or day 2 (3rd-4th), which would then suppress electron levels. Once any CME influence subsides, or if the arrivals are weak, then flux levels are expected to become increasingly High, from day 2 (4th), but particularly day 3 (5th) onward. If no CME arrival occurs, increasingly prolonged periods of high flux is possible from later day 1 (3rd) onward
The associated electron 24 hour fluence is likely to remain below the Active (1e8 integrated pfu) threshold, but with a rising trend and with some significant uncertainty due to the potential CME glances. Should these miss, there is the potential for electron flux to rise to Active early in the period, but most likely rising above this level through days 3 and 4 (5th and 6th). REFM is currently giving good guidance for an upwards trend, but only in the absence of any CME arrival.

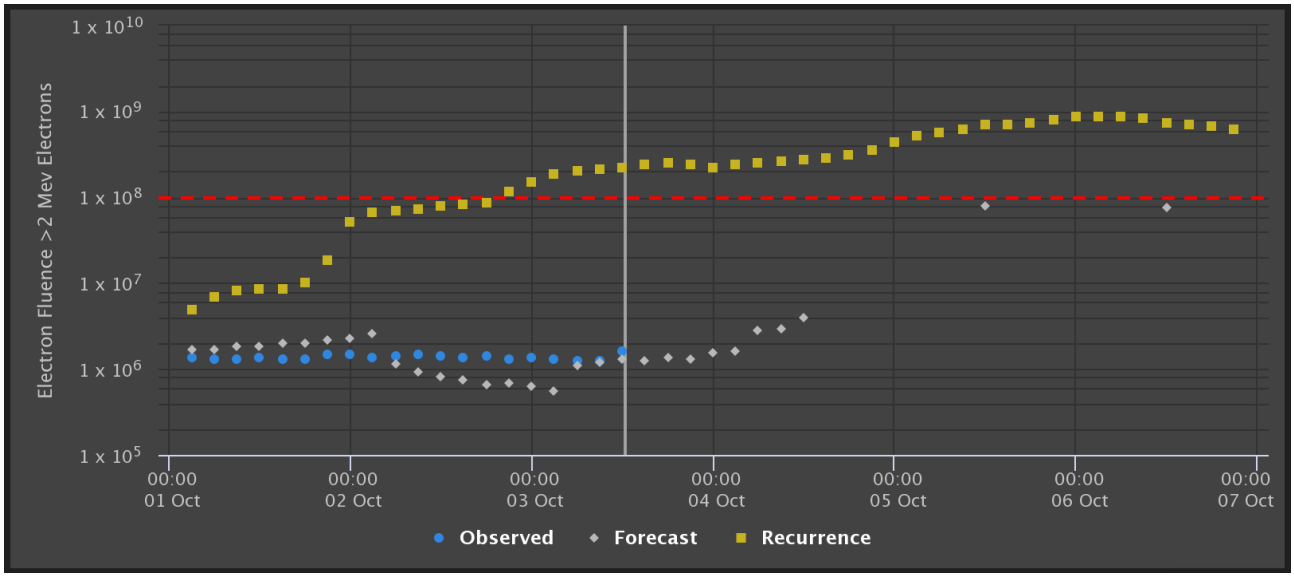
GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	10	20	40	60
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	5

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.

Figure 4: MOSWOC REF Model forecasting increases in fluence levels on days 3 and 4 (5th and 6th)

*



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.